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[54] **EVAPORATIVE EMISSION CONTROL SYSTEM WITH VENT VALVE**

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[52] **U.S. Cl.** .... **123/520**; 123/198 D

[58] **Field of Search** .... 123/520, 198 D, 516, 123/518, 519, 521

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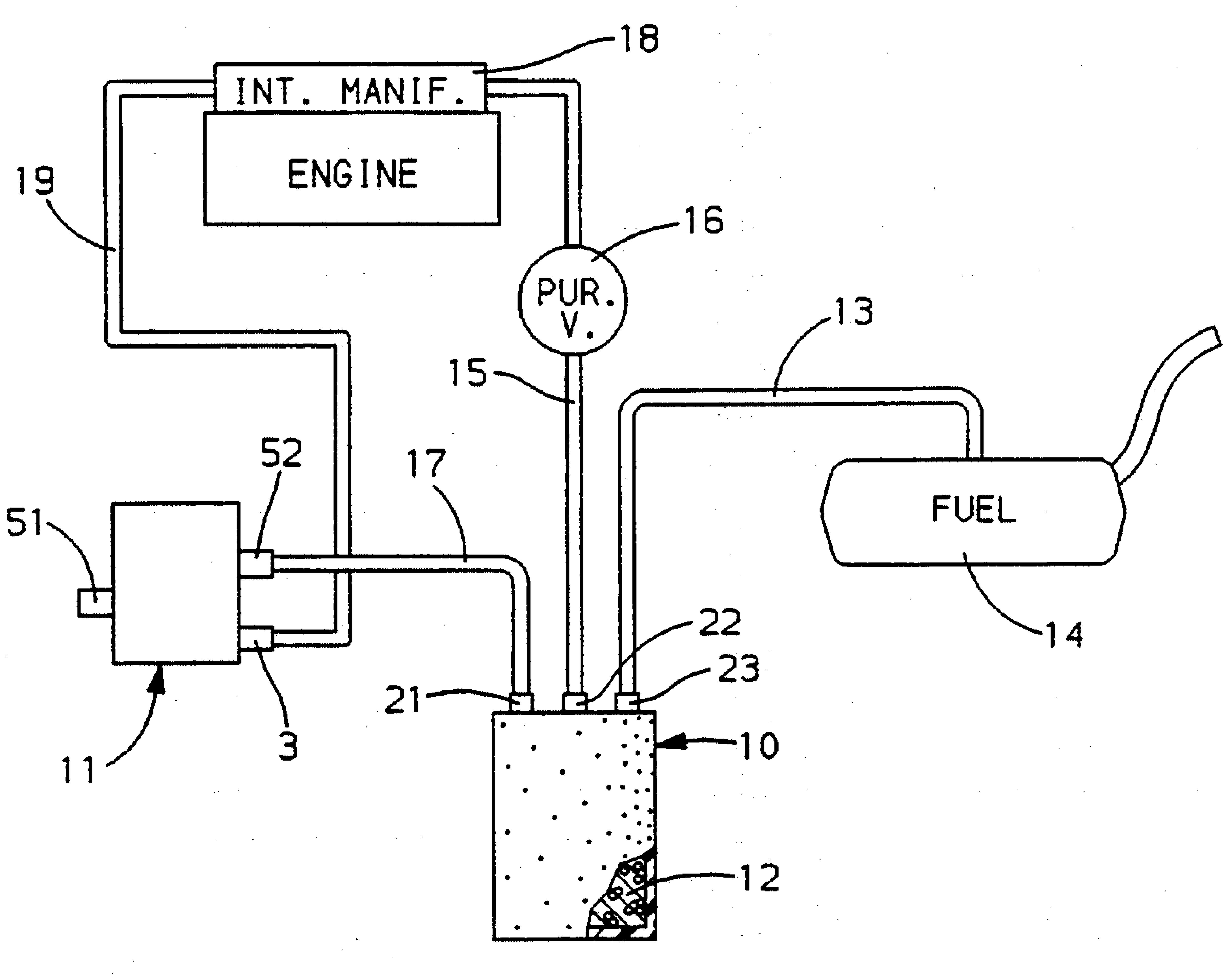
[57] **ABSTRACT**

An evaporative emission control system of an internal combustion engine's fuel system including a vent valve. The vent valve provides a mechanism for closing the evaporative emission control system creating a pressure differential between system and atmospheric under various conditions whereby the system can be automatically diagnosed. The vent valve relieves pressure or vacuum in the system that exceeds a threshold necessary to detect the presence of leaks. The vent valve includes a vacuum actuator providing a low restriction flow path for system purges.

4 Claims, 1 Drawing Sheet



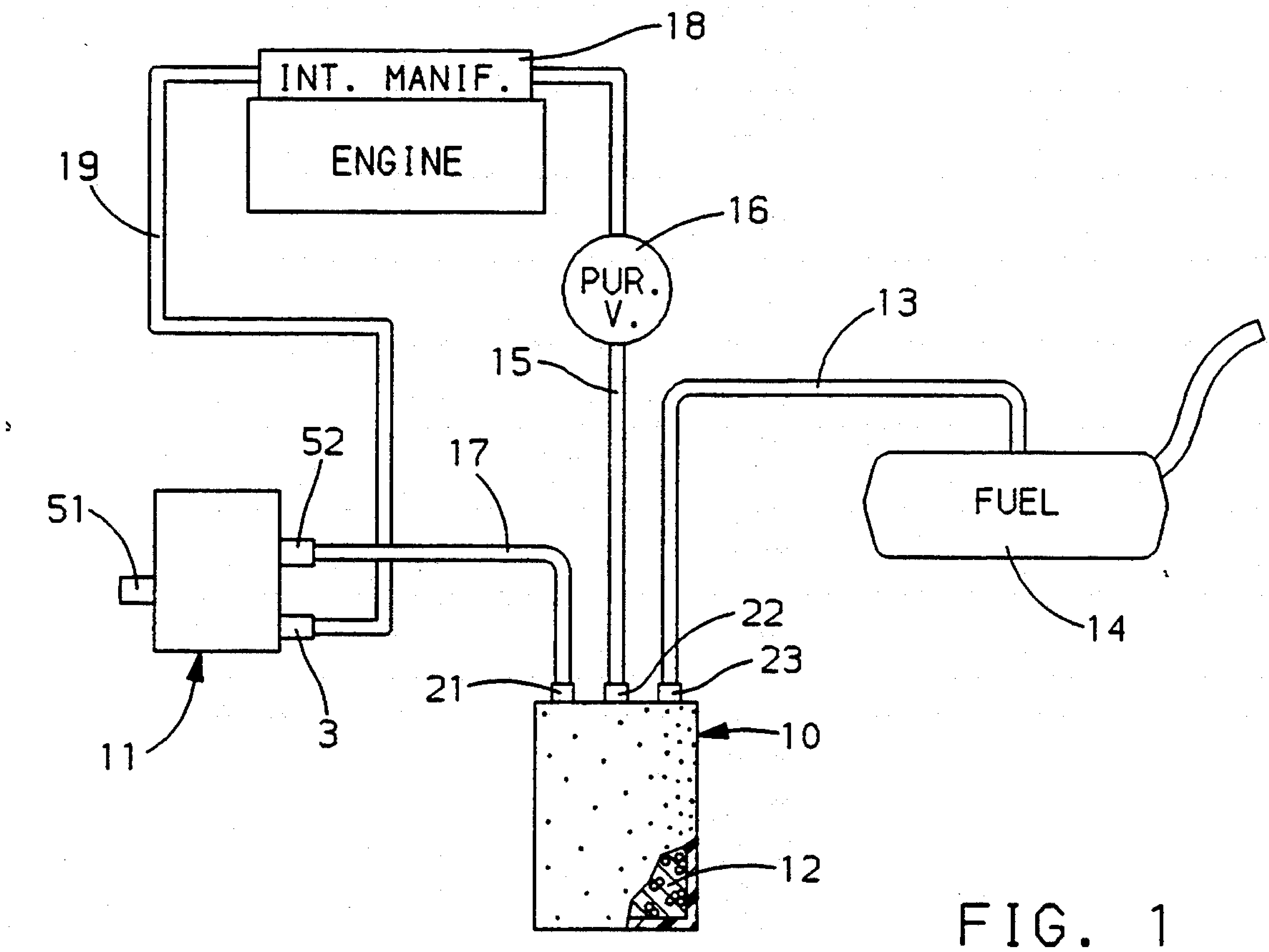

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FIG. 1

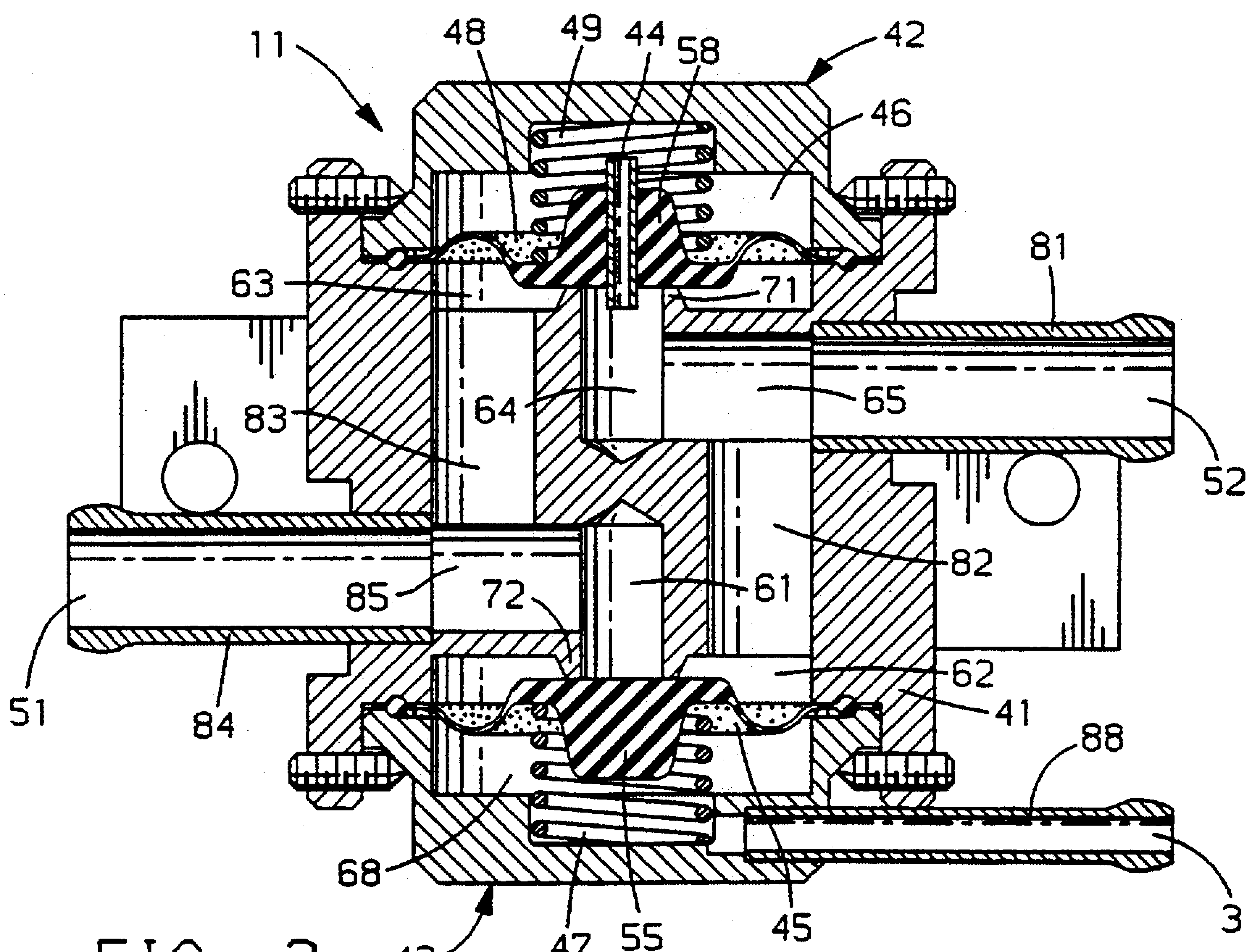
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FIG. 2

EVAPORATIVE EMISSION CONTROL SYSTEM WITH VENT VALVE

BACKGROUND OF THE INVENTION

The present invention pertains to an evaporative emission control system for a vehicle. More particularly, the invention is directed to a system with a vent valve installed in a vent from the evaporative emission control system storage canister for use in system diagnosis.

Automobiles currently include a system for the collection and processing of fuel evaporate created by fuel carried in the fuel system of the automobile, primarily the storage tank. The type of evaporative emission control system involved in the present invention is the evaporative emission canister storage method. This method is comprised of a mechanism to transfer fuel vapor and air emanating from the fuel tank to a canister typically containing activated carbon as an adsorbent for adsorption, storage and later recovery of the vapor.

Adsorption is a reversible process in which gas or liquid particles adhere in a thin film to the surface area of the solid adsorbent. The fuel vapor that is collected in the storage canister is held by the adsorbent when the vehicle is not operating and under certain operating conditions. When the vehicle's engine is running and selected operating criteria are met the vapors are purged from the adsorbent. During the purge cycle, the stored fuel vapor is stripped from the adsorbent by passing ambient air through the adsorbent bed and then mixing it with the intake air flow of the engine for consumption in the normal combustion process. The adsorbent is thereby regenerated by the purge cycle.

The adsorption-desorption process is dynamic and ongoing with the cyclic operation and parking of an automobile that results from a typical operator's use of the vehicle for transportation. Vapors emitted during periods the vehicle is parked are adsorbed and then later desorbed when the vehicle is driven. It is important to provide a free flow of air through the canister during the purge cycle to thoroughly strip the stored vapor from the adsorbent. This results in thorough desorption while the vehicle is in operation thereby providing adsorption capacity for later parked periods.

The storage canister of the evaporative emission control system generally has three port openings leading to the adsorbent bed. A first opening is connected to a line that allows air and fuel vapor to pass from or to the vehicle's fuel tank according to pressure gradients in the tank. A second opening is connected to a line leading to the intake manifold of the vehicle's engine allowing purged vapor and air to pass to the engine according to selected engine operating conditions. The third opening is typically vented to the atmosphere allowing the canister to breathe freely.

By permitting air flow between the canister and atmosphere, the vent facilitates evaporate transfer between the canister and fuel tank and supplies air for canister purge. The vent permits fuel tank evaporate to enter the canister during periods of rising pressure within the tank by acting as a pressure relief point for the system. Evaporate may also return to the tank from the canister during periods of falling pressure in the tank, with the vent relieving vacuum in the system by providing an air entry point. Additionally, during a purge cycle air is drawn through the vent into the adsorbent bed of the canister stripping evaporate and

carrying it to the engine for consumption. The vent to the atmosphere is therefore, an essential component of the evaporative emission control system.

The system, generally as described, was introduced to use in automobiles to reduce hydrocarbon emissions from the fuel system of vehicles and is in widespread use in automobiles today. The most common current mechanism for diagnosing existing evaporative emission control systems is through manual inspection and testing of a system. However, technology has progressed to the point that efforts have been made to provide an automatic mechanism to diagnose systems. Attempts have been made to close systems to a greater extent and provide an automatic diagnostic means. Automatic systems known in the art generally include a valve in the evaporative emission control system's canister vent that is coupled to the vehicle's electronic control module or electrical system.

SUMMARY OF THE INVENTION

This invention is directed to a device that: (A) provides a high degree of vapor closure to an automobile's evaporative emission control system while still allowing free flow of purge air into the system, (B) aids in the automatic detection of system malfunctions, (C) functions automatically, independent of the vehicle's electric and electronic systems, and (D) can be utilized with minimal changes to a present evaporative emission control system.

This device comprises a vent valve having two flow ports with a combination of two flow paths within the valve. The flow paths define two parallel routes through the valve between the flow ports. Each flow path includes an independently acting normally closed valve. A first operator opens one valve at a subatmospheric reference value permitting flow at a selected negative system pressure. A second operator opens the other valve at a superatmospheric reference value permitting flow at a selected positive system pressure and is also actuated by engine intake manifold vacuum pressure at a selected subatmospheric reference value. This valve permits the system to breathe as is required for proper operation while at the same time closes the system according to preset conditions for use in automatically diagnosing the system.

The evaporative emission control system of the present invention includes a storage canister containing an adsorbent material preferably activated carbon. This canister receives and stores fuel evaporate. A connection from the canister is provided to the vehicle's fuel tank to allow evaporated fuel to enter the canister for collection. The canister is also connected to the vehicle's engine intake manifold. This connection includes a solenoid valve that activates and deactivates the purge cycle whereby fuel vapors stored in the canister can be transferred to the engine and consumed during selected engine operating conditions. The vacuum created by the induction system of the engine draws purged vapors from the canister for burning during the normal combustion process along with fuel from the vehicle's fuel supply system.

Also connected to the canister is a vent line leading to the system's vent valve which incorporates the features of this invention. The vent valve includes two flow ports. One flow port is connected to the vent line leading to the adsorbent bed of the canister. The other port opens to the atmosphere. The vent valve controls flow in both directions between the adsorbent bed and the atmosphere. Flow through the vent valve is controlled by the dually arranged valve and flow path system.

The vent valve provides several important functions. Flow is actuated under a plurality of system and vehicle conditions. When the vehicle's engine is running an engine manifold signal opens the valve providing a low restriction flow path for purge air into the canister. Purge air freely flows to the canister stripping fuel vapors that have been stored in the adsorbent material and carrying them through the purge line to the engine for consumption when the purge solenoid valve is open.

The evaporative emission control system vent valve provides an integral part of a diagnostic mechanism for analyzing system parameters. When the engine is off the valve closes sealing the evaporative emission control system from the atmosphere causing pressure to build up. The build up of pressure may be either positive or negative within the system due to external environmental conditions causing a temperature change in the tank or hot soak causes. The pressurized system provides a mechanism whereby sensors can be used to supply information to the vehicle's electronic system or other equivalent apparatus for analysis of the system's functions.

If negative or positive pressure within the system increases beyond a threshold level necessary to detect the presence of malfunctions, such as a leak, the vent valve vents the excess pressure to the atmosphere. This function serves to avoid high levels of pressure in the system and permits back flow of vapor into the vehicle's fuel tank under negative pressure conditions resulting in reduced canister loading.

An aspect of the present invention is that the vent valve does not require electrical power to operate and is not controlled by the vehicle's electronic controls. As a result there is no power drain when the vehicle is off and no direct connection between the valve itself and the vehicle's electronic control module is required. The provision for an engine manifold vacuum actuator integral with the positive system pressure control valve of the vent valve yields the benefit of a low restriction flow path for purge cycle air flow.

The evaporative emission control system vent valve according to the present invention closes the vent to the atmosphere while the vehicle is parked except under extra pressure conditions. By thus closing the system and allowing pressure to build under conditions which would normally be expected to result in a pressure gradient within the system, malfunctions in the vehicle's evaporative emission control system can be detected via the electronic control module of the vehicle. The vehicle's electronics can in turn notify the operator of the system's service requirements.

The above stated objects features and advantages of the invention along with others will become apparent from the following description and illustration of the invention and the presently preferred embodiment thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic of the basic components of an evaporative emission control system according to the present invention including the system's vent valve.

FIG. 2 is a sectional view of the evaporative emission control system's vent valve showing a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

FIG. 1 illustrates an evaporative emission control system of an automobile employing principles of the present invention. This system includes a vapor storage canister **10** containing an adsorbent bed **12** typically activated carbon. This canister provides a closed container for the adsorbent bed **12** with the exception of three port openings **21**, **22** and **23**. Opening **23** is connected to the vehicle's fuel tank **14** via a conduit identified as vapor line **13**. Through this connection fuel evaporate may exit the tank **14** travel through vapor line **13**, enter the canister **10** and be adsorbed by the adsorbent **12**. Vapor line **13** also provides a route whereby decreases in system pressure below atmospheric will draw air into the canister through vent line **17** to strip vapors held in the adsorbent **12** and carry them back to the fuel tank **14**. Therefore, a vent is provided through canister opening **21** for tank **14** as is necessary for a container carrying a variable fluid volume.

Canister opening **22** is connected to a conduit identified as purge line **15** which leads to the vehicle's engine intake manifold system **18**. Positioned in purge line **15** is valve **16** that activates and deactivates flow thereby controlling the purge cycle of the adsorbent **12**. Purge valve **16** is preferably a solenoid operated valve controlled by a conventional vehicle electronic controller (not illustrated). This purge solenoid is normally closed when the vehicle is not running. Valve **16** is typically opened and purge initiated when the engine is running above idle speed. When valve **16** is open atmospheric air is drawn in through vent line **17** and passes through the adsorbent bed **12** mixing with stored fuel vapor. The air-vapor mixture is then drawn through purge line **15** into the intake manifold of the engine **18** where it is consumed.

Canister opening **21** is connected to vent line **17** leading to vent valve **11**. FIG. 2 illustrates vent valve **11** in greater detail. The main components of vent valve **11** include a housing **41**, negative pressure control valve assembly **42**, positive pressure control valve assembly with integral engine vacuum actuator **43**, atmosphere port **51** and canister port **52**. Valve assembly **42** and valve assembly **43** operate as two independent valves to control system pressure. In combination these components provide a mechanism that automatically controls flow between the canister **10** and the atmosphere through ports **51** and **52** of the vent valve **11**.

The valve assembly **42** includes a diaphragm **48** that divides the valve into two chambers **46** and **63**. The chamber **63** is open to the port **51** and therefore the atmosphere via a conduit comprised of bores **83** and **85** in the housing **41** and a tube **84** fitted to the housing **41**. Another conduit provides a flow path from the port **52** to the valve **42**. This conduit is comprised of a tube **81** fitted to the housing **41** and bores **65** and. **64** in the housing **41**, the end of the bore **64** forming a valve seat **71** coaxially facing the diaphragm **48**. The diaphragm **48** carries a valve element **58** adapted for coaction with the valve seat **71**. A spring **49** disposed in the chamber **46** biases the diaphragm **48** and the valve element **58** toward the valve seat **71** to establish a normally closed valve condition. An orifice **44** extends through the valve element **58** and provides a flow path between the bore **64** and the chamber **46** so that the pressure in the chamber **46** will track the pressure in the bore **64** which in turn is essentially equal to the system pressure in the canister **10**.

The conduit comprised of the tube **81** and bores **65** and **64**, the valve **42** and the conduit comprised of the bores **83** and **85** and the tube **84** form a first flow path between the ports **51** and **52**. This path is normally closed by the valve **42** as a result of the force of the spring **49** on the diaphragm **48**. The diaphragm is moved to unseat the valve element **58** from the valve seat **71** to open the first flow path when the pressure in the chamber **46** is decreased below atmospheric pressure by an amount where the force acting on the diaphragm **48** overcomes the force of the spring **49**. This amount is the subatmospheric reference value for the operation of valve **42**.

The valve **43** includes a diaphragm **45** that divides the valve into two chambers **62** and **68**. The chamber **62** is open to the port **52** via a conduit comprised of a bore **82** and the bore **65** in housing **41** and the tube **81**. The chamber **62** is therefore exposed to the pressure in the canister **10** via the conduit **17**. The chamber **68** is open to the port **3** via a tube **88** and therefore exposed to the engine manifold **18** pressure through line **19**. Another conduit provides a flow path from the port **51** to the valve **43**. This conduit is comprised of the tube **84**, the bore **85** and a bore **61** in the housing **41**, the end of the bore **61** forming a valve seat **72** coaxially facing the diaphragm **45**. The diaphragm **45** carries a valve element **55** adapted for coaction with the valve seat **72**. A spring **47** disposed in the chamber **68** biases the diaphragm **45** and the valve element **55** toward the valve seat **72** to establish a normally closed valve condition.

The conduit comprised of the tube **81** and bores **65** and **82**, the valve **43** and the conduit comprised of the bores **61** and **85** and the tube **84** form a second flow path between the ports **51** and **52** that is in parallel with the first flow path through the valve **42**. This second path is normally closed by the valve **43** as a result of the force of the spring **47** on the diaphragm **45**. The diaphragm is moved to unseat the valve element **55** from the valve seat **72** to open the second flow path when the pressure in the chamber **68** is decreased below atmospheric pressure by an amount where the force acting on the diaphragm **45** overcomes the force of the spring **47** or when the pressure in the chamber **62** is raised above atmospheric pressure by the amount where the force acting on the diaphragm **45** overcomes the force of the spring **47**. These amounts constitute, respectively, the subatmospheric and superatmospheric reference values for the operation of valve **43**.

Valve assembly **43** provides two valving functions. When the vehicle's engine is operating a pressure lower than atmospheric is induced in the engine intake manifold **18** creating a vacuum in conduit **19** and in turn in port **3** of vent valve **11**. When greater than the reference value, this subatmospheric condition prompts the operation of valve **43**. Diaphragm **45** overcomes the force of bias spring **47** unseating the valve element **55** from the valve seat **72**. This opens a flow path between chamber **61** and chamber **62** permitting flow between ports **51** and **52** and therefore between the atmosphere and the canister **10**. Operating valve **45** in this manner provides a free flow path for purge air to canister **10** when the vehicle is running, whenever operating conditions initiate a purge cycle. Low restriction flow is important to an efficient purge cycle. Such a flow will be induced by the subatmospheric pressure created by the engine manifold vacuum through the canister **10** to purge adsorbent **12** of stored vapors whenever the purge valve **16** is open. Purge valve **16** is opened by the vehicle electronic controller under preset engine operating conditions such as: when the engine is warm, after the engine has been running a specified time, when the vehicle is operating above a specified road speed and when the engine is operating above a specified throttle opening.

When the engine is not operating, valve assembly **43** permits excess pressure that builds up in the evaporative emission control system to vent to atmosphere through port **51**, when beyond a threshold level necessary to determine the presence of a leak in the system by a diagnostic mechanism. This serves to avoid high levels of superatmospheric pressure in the system.

As pressure builds above atmospheric in the system due to environmental conditions causing fuel expansion in the storage tank **14** or similar occurrences, the pressure in chamber **62** will unseat valve element **55** from seat **72** when the pressure differential exceeds the force of bias spring **47**. The preferred preset force applied by bias spring **47** will be overcome when a superatmospheric pressure of ten inches of water is reached in the system. The amount of pressure necessary to vent the system can be easily varied by changing the bias force of spring **47**. When the pressure in the system is more than the preferred superatmospheric reference value of ten inches of water above atmospheric pressure, the system will vent to atmosphere through port **51** of vent valve **11**. Flow from the system will pass through canister **10** for exposure to adsorbent **12** and removal of fuel vapors prior to being routed to valve **11** through conduit **17** and vented to the atmosphere.

Valve assembly **42** provides the function of relieving excess negative system pressure beyond a threshold level necessary to detect the presence of a leak in the evaporative emission control system. When the internal system pressure drops below atmospheric, a corresponding drop in pressure will occur in port **52** of vent valve **11** and in chamber **64**. This subatmospheric pressure will bleed through orifice **44** to cavity **46**. When the subatmospheric pressure is great enough to overcome the force of bias spring **49**, valve element **58** will be drawn off seat **71**. The preset bias force of spring **49** is preferably overcome when the pressure differential exceeds ten inches of water. This maximum ten inches of water vacuum in the system can be easily varied by changing the amount of bias applied by spring **49**.

When valve element **58** is unseated a flow path is opened between chambers **63** and **64** allowing atmospheric air to be drawn into the system relieving excess subatmospheric pressure. As air is drawn into the system it travels through vent valve **11**, out port **52**, through conduit **17** to the adsorbent bed **12** of canister **10** where stored vapors are stripped from the adsorbent. These vapors then travel through conduit **13** to tank **14** thereby reducing canister adsorbent loading.

The normal biased closed position of valve assemblies **42** and **43** causes positive or negative pressure to build in the evaporative emission control system when the vehicle is parked and ambient conditions change. When ambient conditions vary, a change of pressure within a properly functioning evaporative emission control system can be predicted. This provides a mechanism whereby a diagnostic system can measure the internal system pressure and determine if a leak or other nonpreferred condition exists in the evaporative emission control system.

While this invention has been described in terms of a preferred embodiment thereof, it will be appreciated that other forms could readily be adapted by one skilled in the art. Accordingly, the scope of this invention is to be considered limited only by the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An evaporative emission control system for a vehicle having an internal combustion engine with an intake manifold and a fuel system, comprising:

a canister having a cavity with a first opening for transferring fuel evaporate between the fuel system and the cavity, a second opening for transferring fuel evaporate from the cavity to the intake manifold and a third opening for venting the cavity to atmosphere; and

a vent valve for controlling flow between the cavity and atmosphere including:

a housing having a canister port in communication with the third opening of the canister cavity, an atmosphere port in communication with the atmosphere, an actuator port in communication with the intake manifold and parallel first and second flow paths between the canister port and the atmosphere port:

a first normally closed valve disposed in the first flow path including an operator responsive to subatmospheric pressure in the evaporative emission control system for opening the first normally closed valve;

a second normally closed valve disposed in the second flow path including an operator in communication with the actuator port responsive to superatmospheric pressure in the evaporative emission control system and responsive to subatmospheric pressure in the actuator port from the intake manifold for opening the second normally closed valve.

2. An evaporative emission control system for a vehicle having an internal combustion engine with an intake manifold and a fuel tank, comprising:

a vapor storage canister;

a vapor line connected between the fuel tank and the canister for conveying fuel vapors and air between the fuel tank and the canister;

a vent line connected between the canister and atmosphere, wherein evaporative emission control system internal pressure in the canister is communicated to the vent line;

a purge line connected between the canister and the intake manifold for conveying fuel vapor and air from the canister to the intake manifold;

a vent valve connected to the vent line for controlling flow between the canister and the atmosphere, the vent valve comprising first and second parallel flow paths, the first flow path including a first normally closed valve and a first valve operator exposed to pressure in the vent line and the second flow path including a second normally closed valve and a second valve operator exposed to pressure in the vent line;

a vacuum line connected between the intake manifold and the second valve operator exposing the second valve operator to pressure in the intake manifold;

the first valve operator being responsive to subatmospheric pressure in the evaporative emission control system lower than a first subatmospheric reference value for opening the first normally closed valve thereby enabling flow between the canister and the atmosphere; and

the second valve operator being responsive to each of a superatmospheric pressure in the evaporative emission control system exceeding a superatmospheric reference value and a subatmospheric pressure in the vacuum line from the intake manifold lower than a second subatmospheric reference value for opening the second normally closed valve thereby enabling flow between the canister and atmosphere.

3. An evaporative emission control system for a vehicle having an internal combustion engine with an intake manifold and a fuel tank, comprising:

a vapor storage canister;

a vapor line connected between the fuel tank and the canister for conveying fuel vapors and air between the fuel tank and the canister;

a vent line connected between the canister and atmosphere;

a purge line connected between the canister and the intake manifold, the purge line including a normally closed purge valve that is opened during engine operation exposing the canister to subatmospheric pressure in the intake manifold to purge fuel vapor from the canister by enabling air flow therethrough from the vent line to the intake manifold;

a vent valve in the vent line for controlling flow between the canister and the atmosphere, the vent valve comprising first and second parallel flow paths, the first flow path including a first normally closed valve and a first valve operator exposed to pressure in the vent line and the second flow path including a second normally closed valve and a second valve operator exposed to pressure in the vent line;

a vacuum line connected between the intake manifold and the second valve operator exposing the second valve operator to pressure in the intake manifold;

the first valve operator being responsive to subatmospheric pressure in the evaporative emission control system lower than a first subatmospheric reference value for opening the first normally closed valve thereby enabling flow between the canister and the atmosphere; and

the second valve operator being responsive to each of a superatmospheric pressure in the evaporative emission control system exceeding a superatmospheric reference value and a subatmospheric pressure in the vacuum line from the intake manifold lower than a second subatmospheric reference value for opening the second normally closed valve thereby enabling flow between the canister and atmosphere,

whereby flow between the canister and atmosphere is enabled when the vent valve is opened in response to subatmospheric pressure in the intake manifold lower than the second subatmospheric reference value during engine operation and when the pressure in the evaporative emission control system exceeds the superatmospheric reference value or is lower than the first subatmospheric reference value to enable collection and purging of fuel vapor and the vent valve being closed when the engine is off and the pressure in the evaporative emission control system is between the superatmospheric reference value and the first subatmospheric reference value to enable diagnosis of the evaporative emission control system.

4. An evaporative emission control system for a vehicle having an internal combustion engine with an intake manifold and a fuel tank, comprising:

a vapor storage canister;

a vapor line connected between the fuel tank and the canister for conveying fuel vapors and air between the fuel tank and the canister;

a vent line connected between the canister and atmosphere;

a purge line connected between the canister and the intake manifold, the purge line including a normality closed purge valve that is opened during engine operation exposing the canister to subatmospheric pressure in the intake manifold to purge fuel vapor from the canister by enabling air flow therethrough from the vent line to the intake manifold;

a vent valve in the vent line for controlling flow between the canister and the atmosphere, the vent valve comprising first and second parallel flow paths, the first flow path including a first normally closed valve and a first valve operator exposed to pressure in the vent line and the second flow path including a second normally closed valve and a second valve operator exposed to pressure in the vent line;

a vacuum line connected between the intake manifold and the second valve operator exposing the second valve operator to pressure in the intake manifold;

the first valve operator including a first diaphragm having a first valve element with an orifice therethrough biased toward a first valve seat by a first spring;

the first valve operator being responsive to subatmospheric pressure in the evaporative emission control system lower than a first subatmospheric reference value equal to the spring's biasing force for opening the first normally closed valve thereby enabling flow between the canister and the atmosphere;

the second valve operator including a second diaphragm having a second valve element biased toward a second valve seat by a second spring; and

the second valve operator being responsive to each of a superatmospheric pressure in the evaporative emission control system exceeding a superatmospheric reference value equal to the second spring's biasing force and a subatmospheric pressure in the vacuum line from the intake manifold lower than a second subatmospheric reference value equal to the second spring's biasing force for opening the second normally closed valve thereby enabling flow between the canister and atmosphere,

whereby flow between the canister and atmosphere is enabled when the vent valve is opened in response to subatmospheric pressure in the intake manifold lower than the second subatmospheric reference value during engine operation and when the pressure in the evaporative emission control system exceeds the superatmospheric reference value or is lower than the first subatmospheric reference value to enable collection and purging of fuel vapor and the vent valve being closed when the engine is off and the pressure in the evaporative emission control system is between the superatmospheric reference value and the first subatmospheric reference value to enable diagnosis of the evaporative emission control system.

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